

Dilemma japonicum new species (Bivalvia: Anomalodesmata: Poromyidae): A new record of the genus from the Northwest Pacific

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ABSTRACT

The fourth species of the bivalve genus *Dilemma* Leal, 2008, is described from disarticulated valves collected off central Japan. The discovery of these specimens represents a significant range extension for the genus to the Northwest Pacific. The new species is distinguished from the other three known species by its surface sculpture, shape of esutcheon, and hinge. The prodissoconch, indicative of lecithotrophic development, and shell microstructure, with outer homogeneous and inner nacreous layers, are illustrated for the first time for a species of the genus.

Additional Keywords: Septibranchia, Poromyoidea, Japan, nacreous layer, prodissoconch

INTRODUCTION

Dilemma is a recently established, unusual genus of Anomalodesmata (Leal, 2008). The first described species of the genus, *D. inexpectatum* (Crozier, 1966), was dredged from bathyal depths off northern New Zealand and originally assigned to *Corculum*, family Cardiidae (Crozier, 1966) due to general similarities in shell shape. However, its original familial allocation was questionable from habitat and depth alone, because *Corculum* species inhabit shallow lagoons of tropical waters and utilize photosynthesis-derived energy by symbiotic dinoflagellates (Farmer et al., 2001). Subsequent discovery of obviously related species with preserved soft parts allowed Leal (2008), using details of the macroanatomy, to demonstrate (1) that *Corculum inexpectatum* and the other, then newly found species are related and deserved grouping under a new genus, (2) that the new genus should be included in the Poromyidae, and (3) that species of *Dilemma* are carnivores. In fact, carnivory is a feeding habit that is common in the Anomalodesmata, a group of bivalves mostly present in the deep sea.

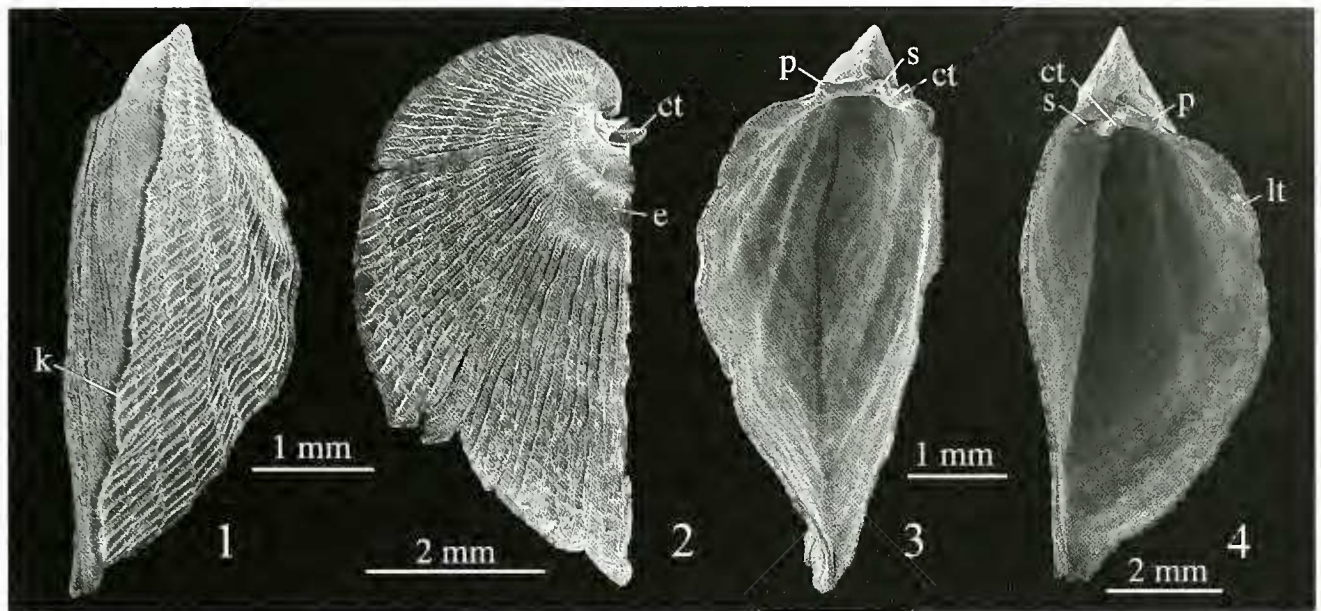
Three species were originally (Leal, 2008) assigned to the genus: (1) *Dilemma frummarkernorum* Leal, 2008,

from off Key West Florida, 229 m, (2) *D. spectralis* Leal, 2008, from off Vanuatu, 950–961 m, and (3) *D. inexpectatum* (Crozier, 1966) from off Three Kings Islands, New Zealand, 805 m. Their geographic distribution is disjunct, but shell morphology is surprisingly similar between the species of Florida and Southwest Pacific.

During a research cruise off central Japan, in 2000, the senior author collected small unpaired valves of *Corculum*-like bivalves, but its locality (240–273 m) was obviously too deep for *Corculum*. In addition, the inner shell layer is iridescent, indicating presence of a nacreous layer. This conchological feature alone precluded inclusion of this new species in the Cardiidae. However, lack of soft parts prevented a better resolved familial or supra-familial placement of the new taxon. The publication by Leal (2008) allowed allocation of the unknown bivalve in that newly established genus of the Poromyidae. In this paper, we describe this most interesting new species and report a new record of the genus from the Northwest Pacific.

MATERIALS AND METHODS

Four unpaired valves were sorted from sediments dredged from southeast of Kamogawa, Chiba Prefecture, Japan, with a biological dredge (R/V TANSEI-MARU, cruise KT-00-05, station 1, 240–273 m, 34°59.963' N, 140°27.159' E–35°00.020' N, 140°28.427' E, May 17, 2000). All specimens were dead and disarticulated. The shells were coated with platinum and vanadium and photographed with a scanning electron microscope (Hitachi S-2250N), following a standard method (see Geiger et al., 2007). The holotype and two paratypes are deposited in the Department of Historical Geology and Paleontology, The University Museum, The University of Tokyo (UMUT), and one paratype in The Bailey-Matthews Shell Museum, Sanibel, Florida (BMSM).



Figures 1–4. *Dilemma japonicum* new species. 1. Lateral view. 2. Posterior view. 3–4. Interior view. 1–3. Left valve. 4. Right valve. 1. Holotype, UMUT RM 296S9. 2. Paratype 1, UMUT RM29690. 3. Paratype 2, UMUT RM29691. 4. Paratype 3, BMSM 179S3. Abbreviations: **ct** = cardinal-like tooth; **e** = escutcheon; **k** = keel; **lt** = lateral tooth; **p** = projection in hinge; **s** = socket.

SYSTEMATICS

Superfamily Poromyoidea Dall, 1886

Family Poromyidae Dall, 1886

Genus *Dilemma* Leal, 2008

Type Species: *Dilemma frumarkernorum* Leal, 2008, by original designation.

Diagnosis: Shell compressed anteroposteriorly and expanded laterally; lateral outline of articulated valves cardioid; umbones projecting dorsally and located anteriorly; sharp oblique carina dividing anterior and posterior regions; maximum growth axis having ca. 30° against anteroposterior axis; hinge axis short with cardinal-like tooth and socket in each valve; lateral tooth reduced, present only in right valve; ligament external, double-layered; lithodesma absent; shell interior lined with sheet-like nacreous layer. See Leal (2008) for anatomical characters.

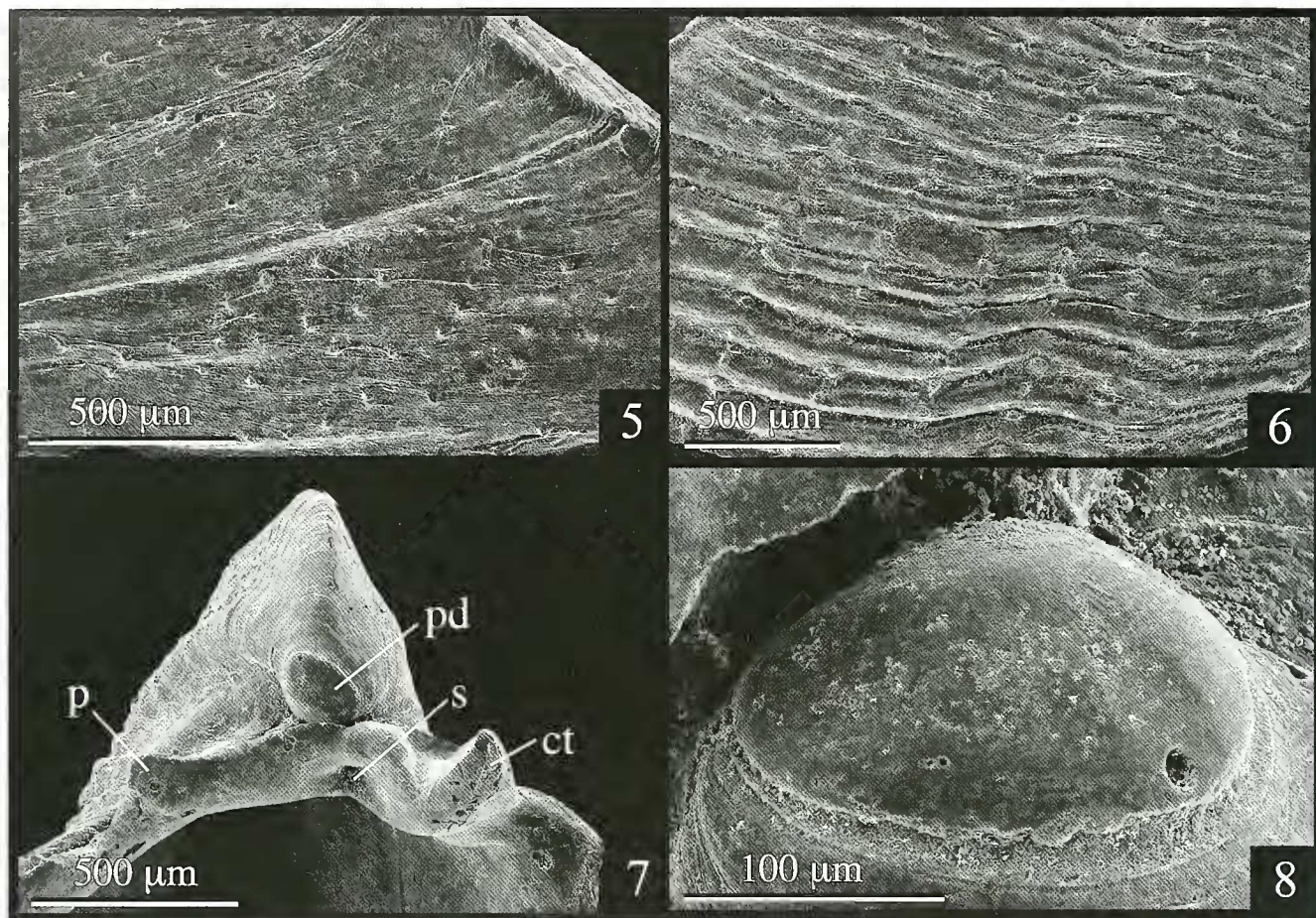
Dilemma japonicum new species
(Figures 1–12)

Diagnosis: Posterior region of shell sculptured by rough, lamellate, thin, commarginal ribs; surface irregularly punctate on anterior region but puncta radially arranged on posterior region; escutcheon not distinctly demarcated; prominent projection present in posterior region of hinge.

Description: Shell thin, fragile, compressed anteroposteriorly; shell height larger than shell length. Anterior and posterior regions clearly demarcated by sharp keel (Figure 1, **k**); anterior region narrower and less inflated

than posterior. Surface of anterior region smooth, flattened in macroscopic view, but microscopically punctate (Figure 5). Surface of posterior region sculptured by several weak radial ribs (Figure 3), and more prominently so by dense commarginal ribs, also punctate in enlarged view, but puncta arranged neatly in radial direction unlike on anterior region (Figure 6). Umbo angulated by keel and rib along posterior margin (Figure 7); umbonal cavity deep; umbo involute (Figure 3). Prodissoconch simple, flattened, shield-like, ca. 200 µm in length, without prominent sculpture or division into prodissoconch I and II (Figure 8). Hinge provided with single cardinal-like tooth and socket on each valve (Figures 3–4, 7, **ct**, **s**); cardinal-like tooth located anterior to socket on left valve (Figure 3), their position reversed on right valve (Figure 4). Lateral tooth small, present only on right valve (Figure 4, **lt**). Single sharp projection (Figures 3–4, 7, **p**) prominent on posterior side of hinge in similar position and size in right and left valves. Ligament and outlines of muscle scars not observed in disarticulated valves. Shell margin consisting of two layers, outer homogeneous structure and inner nacreous structure (Figure 9–10, **OL**, **IL**). In outer layer elongate granules arranged vertically but lacking clear boundary. In inner layer suboval tablets fusing in growth region (Figure 11), numerous sheet-like layers forming nacre (Figure 12).

Type Material: Holotype, 4.7 mm (height: SH) × 2.0 mm (length: SL), UMUT RM296S9 (Figure 1); Paratype 1, 5.6 mm (SH) × 2.4 mm (SL), UMUT RM29690 (Figure 2); Paratype 2, 6.0 mm (SH) × 3.0 mm (width), UMUT RM29691 (Figure 3); Paratype 3, 9.3 mm (SH) × 4.0 mm (SL), BMSM 179S3 (Figure 4).



Figures 5–8. *Dilemma japonicum* new species. 5–6. Detail of surface sculpture. 5. Anterior slope. 6. Posterior slope. 7. Detail of hinge. 8. Prodissoconch. 5–6. Holotype, UMUT RM29689. 7–8. Paratype 2, UMUT RM29691. Abbreviations: ct = cardinal-like tooth; p = projection in hinge; pd = prodissoconch; s = socket.

Type Locality: Southeast off Kamogawa, Chiba Prefecture, Japan. 240–273 m, 34°59.963'–35°00.020' N, 140°27.159'–140°28.427' E.

Distribution: Known only from the type locality.

Etymology: The species epithet recognizes the country of the type locality. The epithet *japonicum* agrees in gender with the name *Dilemma*, a late-Latin neuter noun derived from the Greek. Of the previously named species in the genus, *inexpectatum* is a neuter gender epithet, *frummarkernorum* has a genitive ending that is not to be influenced by the gender of the genus, and *spectralis* is an epithet originally used by Leal (2008) as a noun in apposition.

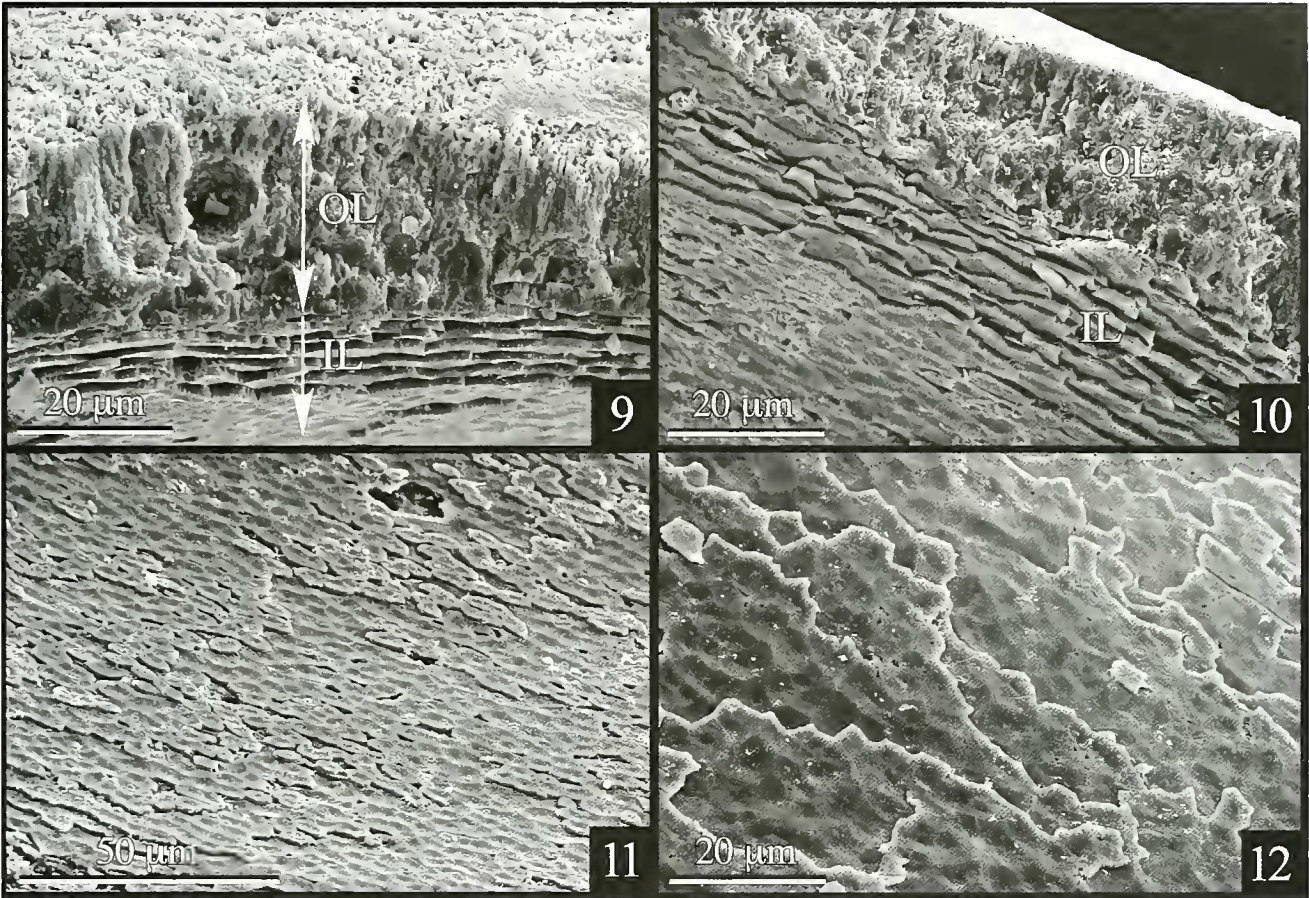
DISCUSSION

The inclusion of the new species in the genus *Dilemma* is well supported by the presence of the diagnostic shell characters of the genus: anteroposteriorly compressed shell, cardioid outline in articulated valves, sharp carina dividing the shell into the anterior and posterior regions,

cardinal-like tooth and socket in each valve, and nacreous shell interior. Obviously there is no other group having a combination of these characters in bivalves.

From the three previously known species of the genus, *Dilemma inexpectatum* (Crozier, 1966) from northern New Zealand is most similar to the new species in having rough commarginal sculpture in the posterior region. However, the two species differ in two characters: the rows of pores are absent and the escutcheon is distinct in *D. inexpectatum*. As summarized in Table 1, the four species in the genus can be distinguished among themselves by four shell characters: sculpture in the posterior region; the presence or absence of small pits; the distinctness of the escutcheon; and the presence or absence of the posterior projection of the hinge. The paired posterior projections are present only in *D. japonicum*; they are not part of the hinge teeth system, because they do not articulate as a tooth and a socket between the right and left valves. Unfortunately, the outlines of muscle scars were unclear in the specimens of the new species.

The original description of *Dilemma* mentioned “Shell apparently nacreous internally . . .” (Leal, 2008: 3), but did not offer any detailed descriptions or discussions



Figures 9–12. *Dilemma japonicum* new species. Shell microstructure. 9–10. Observed at small broken part of shell margin, vertical section of homogenous structure in outer layer (OL) lined by nacreous structure in inner layer (IL). 11–12. Oblique (11) and horizontal (12) views of nacreous layer at inner shell surface. Paratype 2, UMIUT RM29691.

on the shell microstructure of the three originally included species. The description of the inner nacreous shell layer in the present study confirms its presence in *Dilemma*.

A shell consisting of outer homogeneous and inner nacreous layers (Figure 9–12) supports inclusion of the new species in *Anomalodesmata* (Taylor et al., 1973; Prezant, 1995). The microstructure of the outer layer is

somewhat similar to a simple prismatic structure in that elongate granules are arranged vertically. The outer layer is identified as a homogeneous structure, because, unlike typical prismatic structure, crystals lack sharp boundaries. It should be observed, however, that environmental changes can alter otherwise organized shell microstructures to appear irregular, smoothed, and homogeneous (R. Prezant, pers. comm.).

Table 1. Shell characters and distribution of the four *Dilemma* species.

	<i>D. frumarkernorum</i>	<i>D. spectralis</i>	<i>D. inexpectatum</i>	<i>D. japonicum</i> new species
Sculpture in posterior region	Dense, coarse growth lines	Smooth	Rough commarginal ribs and grooves	Rugose, lamellate commarginal ribs
Small pits on exterior surface	Absent	Present	Absent	Present
Escutcheon	Not clearly separated	Not clearly separated	Clearly defined	Not clearly separated
Projection posterior to beak	Absent	Absent	Absent	Present
Distribution	Off Key West Florida, USA, 229 m	Off Vanuatu, Southwestern Pacific, 950–961 m	Off Three Kings Islands, New Zealand, 505 m	Off central Japan, Northwest Pacific, 240–273 m (dead)

The prodissoconch of *Dilemma japonicum* new species indicates non-planktotrophic, lecithotrophic development. It measures ca. 200 μm in length (Figure 8), a size that fits into the predicted size range (135–230 μm) of prodissoconchs of bivalves with lecithotrophic development (Ockelmann, 1965; Jablonski and Lutz, 1983). The developmental modes of the other species of the genus are unknown.

Although two of the other live-collected species of *Dilemma* were found attached to hard substrata, the microhabitat of the new species is unknown. The bottom sediment from the type locality contained numerous dead shells and other biogenic fragments such as those of bryozoans and sponges. Because most bivalves were dead and disarticulated, large part of samples in the dredge haul was inferred to be transported and accumulated. Specifying the actual microhabitat of the species is an interesting target for future sampling.

The description of *Dilemma japonicum* extends the geographic range of the genus to the Northwest Pacific, in addition to previous records from off Florida and the Southwestern Pacific (off Vanuatu and New Zealand). The genus has a broad geographic range, extending across the Panama land bridge and Eastern Pacific barrier. Future sampling of deep-sea hard substrates may yield additional records of *Dilemma* species from other locations in the Pacific and in other oceans.

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